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ABSTRACT

Problem-based learning (PBL) with simulated cases is one method of delivering standardized pediatric curricular objectives, but the fact that students are dispersed and participating in community-based practices makes group meetings difficult. To address these issues, researchers developed and tested a new modality for presenting PBL cases, a CD-ROM/Web hybrid computer program to standardize the national pediatric curriculum: Project Learning through Interactive Video Education (L.I.V.E.). Project L.I.V.E. used digital video case simulations to present PBL with the stimulus case followed by asynchronous case discussions among students at multiple clinical sites. The study sought to determine if critical thinking as shown by discourse among students during group discussion differed by presentation format. Approximately 128 medical students participated in 3 conditions: (1) a face-to-face group with text/paper case modality; (2) a face-to-face group with a video case modality; and (3) a virtual group with digital video case modality. Study findings suggest that the virtual group engaged in more critical thinking, as represented by their dialogue within the group, than did the other two modalities, perhaps because of the increased individual accountability required by the online discussion. However, the virtual group did have a reduced sense of group process. The findings also provide insight into the advantages of using video. (Contains 21 tables and 32 references.) (SLD)

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Paper presented at the 2002 AERA Annual Conference

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Does Project L.I.V.E. Case Modality Impact Critical Thinking in PBL Groups?

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Educators frequently run into a mismatch between what students need to learn and their opportunities to learn in clinical education. Consider the following examples. First, students learning about pediatric care directly with patients may see limited kinds of cases depending on the season. In winter and spring, respiratory diseases predominate, but fall more commonly brings croup and diarrhea with dehydration. However, students must gain competency in understanding and treating all of these clinical pediatric conditions. Second, the Council on Medical Student Education in Pediatrics (COMSEP) reports that students do not have enough time to gain competencies in areas such as child abuse, genetic disease, and adolescent issues during a pediatric clerkship.[1] Third, the clinical portion of medical education is increasingly centered in community-based practices. This decentralization enhances exposure to primary care, but creates difficulty in administering a standard curriculum.

Problem based learning (PBL) with simulated cases is one method of delivering standardized pediatric curricular objectives; however, dispersed students make group meetings difficult. To address these issues, we have developed a new modality for presenting PBL cases, a CD-ROM/web hybrid computer program to standardize the national pediatric curriculum: Project L.I.V.E. (Learning through Interactive Video Education).[2]

While Project L.I.V.E. may resolve some curricular issues, it must also maintain or enhance the goals of PBL. PBL is designed to promote skills in critical analysis, self-directed learning, and problem-solving.[3] Groups scrutinize ideas, which encourages inquiry-based attitudes that depend upon recognizing problems and logically assessing evidence. These skills reflect the construct of critical thinking. Medical educators often discuss teaching methods that encourage in-depth processing, a characteristic of critical thinking. This in-depth processing, or deep learning, is necessary to derive clinical inferences from available data (deductive reasoning), recognize unstated assumptions by weighing evidence, and distinguish between weak and strong arguments.[4] In PBL, students demonstrate this critical thinking in their group discussions. We must ensure that this continues in Project L.I.V.E.

PBL typically uses paper (text) cases that allow the patient's story and physical examination findings to unfold. However, unlike adult patients who can provide a history, pediatric patients very often cannot. Therefore, the text case modality may limit PBL. Physicians must recognize visual and auditory cues to accurately diagnose a child. Using a video case modality rather than text modality may better approximate reality and allow the student to work on observational skills.

Project L.I.V.E. uses digital video case simulations to present PBL. These cases serve as a stimulus for learning followed by asynchronous case discussions among students at multiple clinical sites. This discussion is key to learning in PBL. Thus, the CD-ROM/web hybrid program provides a new "virtual" modality for presenting a PBL case.

While the case is the stimulus in the PBL experience, actual learning occurs during the group's collaborative discussion of the case. Providing structure for students to discuss the case asynchronously with a facilitator was a key component of the program's design. This meant

students had to write their thoughts and arguments rather than speak them. As a result of the reflective and explicit nature of writing, the virtual modality may have inherent advantages over speech in promoting higher order thinking among the group.[5]

This study sought to determine if critical thinking as exemplified by the discourse among students during group discussion differs among groups receiving the same case with the same facilitator in one of three formats. The formats were (1) a face-to-face group with a text/paper case modality, (2) a face-to-face group with a video case modality, or (3) a "virtual" group with a digital video case modality.

Theoretical Framework

The theoretical framework draws from three sources: the relationship of PBL and critical thinking, critical thinking and discourse, and the effect of case modality. To look at the virtual modality particularly in light of discourse requires drawing from the computer mediated communication/conferencing (CMC) literature.

PBL and Critical Thinking. Researchers in Sweden found that after they introduced problem-based learning in the curriculum, students' perceptions that the curriculum encouraged critical thinking significantly increased.[6] The Swedish article was one of the few PBL studies in the medical education literature to mention critical thinking even though its properties appear to be synonymous with many of the goals of a PBL curriculum. Kamin and colleagues (2001) tied a number of concepts measured in PBL to critical thinking.[7] They concluded that critical thinking is a broader construct than the individual constructs of self-directed learning, problem-solving, or creative thinking.

Critical Thinking and Discourse. In the 1990s, Garrison (1991)[8] incorporated the work of Dewey (1933)[9] with that of Brookfield (1987)[10] to propose the following five stages of critical thinking: 1) Problem identification 2) Problem definition, 3) Exploration, 4) Applicability and 5) Integration.

Using Garrison's model as a framework, Newman et al conducted a content analysis of transcripts to measure critical thinking in small group discussions.[11] They developed categories for each of Garrison's five stages. They then applied a concept introduced by Henri (1991) who suggested indicators of surface processing (surface learning, x^s) and in-depth processing (deep learning, x^d), reflecting the learner's level of information processing.[12] Newman and colleagues (1997) applied Henri's concept and, based on their content analysis, developed a code to analyze discourse. This code contained in-depth and surface descriptors within each stage of Garrison's model. Further, they calculated a Critical Thinking Ratio by computing $(x^d - x^s)/(x^d + x^s)$ for each of the five stages.[13] Lack of interrater reliability in coding led Kamin and colleagues to refine this code resulting in interrater agreement exceeding .80.[7]

Two recent studies report on critical thinking and discourse in on-line environments. Bullen (1998) assigned 13 students a score of extensive use of critical thinking (3), moderate use of critical thinking (2), or minimal use of critical thinking (1). The mean critical thinking score was 1.83. Only three students received scores higher than two.[14] Fabro (1998) used surveys, interviews, and focus groups to gain student perspective on effectiveness of computer conferencing to develop higher order thinking skills. Three themes were related to cognition:

written text, delivery, and critical thinking. One, some students said that they had to think more about their responses because they were written, But others felt that communicating in text could contribute to miscommunication. Two, students agreed that critical feedback from the instructor was essential to the course delivery. Three, students said they were hesitant to critically analyze arguments that their peers presented, and suggested modeling and facilitating to promote critical thinking.[15]

Case Modality. Dual coding theory leads us to anticipate differences in outcomes between a digital video case and a text case. Dual coding theory suggests that the use of visualization enhances learning and recall, in part because images and words are processed in different parts of the brain.[16] People remember images better than words because they are more likely to code them redundantly, providing two representations rather than one.[17] This may help reduce cognitive load in working memory aiding learners with a weaker background in the subject matter through visualization of concepts.[18] The learner, an active participant, selectively attends to and scans a stimulus, interpreting important details to perceive meaning.[19, 20] While students might remember visual information more easily, they first have to accurately perceive it.

Researchers studying dual coding theory generally use photographs and some have used animation,[21] but few have used video. We found three studies that examined the impact of video instead of text on learning. LeeSing and Miles (1999) studied digital video, audio, and pictures with text computer presentations and found the only significant difference in outcomes was in time spent to complete the modules.[22] The audio presentation took longer. The digital video was a lecture, not a case simulation.

Bowdish and colleagues (2001) studied face-to-face PBL groups with a computer-based video case (8 groups) and with a text case (8 groups). Overall, the video case groups performed better than the text case groups on a written examination.[23] Sakowski, Rich and Turner (2001) found that students using web-based case simulations as an individual exercise did not perform differently on the clerkship written examination than those in the traditional clerkship curriculum.[24] However, this case simulation lacked a collaborative dialogue about the case. It was also unclear how much of the case was on video or how sensitive the test questions were in detecting learning differences. Overall, few relevant studies could direct our investigation to detect differences based on format.

Methods

Data Sources or Evidence. Approximately 128 third year medical students rotated through the pediatric clerkship in groups of 16 during the eight rotations for the year. For their first PBL case, we placed students in one of three groups, 1) a face-to-face group with a text/paper case 2) a face-to-face group with a video case and 3) a virtual group with the digital video case. The same faculty member facilitated all groups. All groups did the case in the same week of their rotation. Face-to-face sessions lasted 2 to 3 hours across two different meetings with work on learning issues in between sessions. Sessions were audio taped and transcribed. The transcriber removed student identifiers from all group transcripts. The virtual groups had deadlines (e.g., turn in learning issues by Tuesday at 5 p.m.) but they could work at their own convenience during the week. These students had to post their facts about the case and hypotheses before viewing what other students said. Virtual group discussion was collected in an Access database.

PBL Cases. Medical schools generally use two types of PBL cases, free inquiry and guided design. Free inquiry allows students to ask their own questions as they gather data. Guided design merges case method and programmed instruction.[25] Student feedback occurs in the unfolding presentation of the case. We used guided design in a case about a baby with altered mental status. The students learned how to recognize and assess this status and develop a differential that includes child abuse. The text modality allowed the patient's story to unfold in a narrative format and discussion of the case with a facilitator. In the video modality, the students viewed the baby's story. The face-to-face group discussed the case with the facilitator. In the virtual modality, the students saw the baby's presentation unfold in video, but their discussion occurred on-line asynchronously with a facilitator.

Content Analysis. The coder coded the transcripts using a content analysis coding system.[7] The coder was blind to group type. However, some dialogue suggested the modality. For example, "Who wants to be the scribe?" indicates a face-to-face group and, "Does somebody want to read this?" indicates a text case. Also, completed thoughts without interruptions and additions from other students reflected a virtual group dialogue. An example of uninterrupted dialogue from a student in a virtual group follows:

> Student 1: "Yes, I think that this child cries whenever moved or touched and that MOC [mother of child] reports that he has been difficult to arouse and that these both meet the above [referring to another student's comments] criteria. I believe that the $50 phrase for not acting right would be mental status changes, including hyperirritability that can evolve to lethargy and coma."

The coder received identically formatted electronic files without student identifiers. The unit of analysis was the total group dialogue, composed of either the two to three hours of transcription or all of the exchange that occurred on-line. Using the coding scheme, the researcher placed each distinct unit into one of 35 indicators reflective of the five critical thinking stages and group process issues. Interrater agreement on placement exceeded 0.80.[7] For each of the five critical thinking stages, a critical thinking ratio between –1 and +1 was calculated. The critical thinking ratio, $(x^d - x^s)/(x^d + x^s)$, was independent of the quantity of participation, reflecting only the quality of the discussion. Calculating a ratio eliminated the problem of the different amounts of time groups spent discussing the case, since face-to-face groups had limited time. When the hour was up, it was sometimes difficult for students to remain, while virtual groups were unconstrained by time.

Dialogue unrelated to critical thinking or discussing the case reflects group process. To represent all of the dialogue that is occurring we coded group process category into four indicators: rapport building, explaining process, negotiating learning issues, and making a commitment. An example of dialogue coded in rapport building follows:

> Facilitator: "It's funny, but after two cases, I can see where you're going to lead your lives, what professions you're choosing. I just have hunches. I have no idea."
> Student 1: "What are you looking for?"
> Facilitator: "This is the neurosurgeon."
> Student2: "See, if I had my backpack here we'd have all the answers."
> Student 1: "What's in your backpack?"
> Student 2: "Every book known to man. It's going to break my back though."

Data analysis: Since this study involved a small number of groups, we chose univariate analyses and used a non-parametric analysis, the Kruskal-Wallis Test., to compare the critical thinking ratios for each stage across the three types of groups. We considered $p<.1$ to be significant due to the exploratory nature of the study, but we have an inflated Type I error because of the multiple analyses of correlated variables.

Results

Because of transcriber unavailability, technical difficulties, and problems implementing the study, we had complete transcriptions of the first PBL case from 13 of the 24 groups Four groups used the text case, four used the video case, and five groups were virtual with the video case. We calculated five critical thinking ratios for each group corresponding to Garrison's five stages (See Table 1). The correlation among the stages ranges from 0.22 to 0.50 using Kendall's tau. There were significant differences for each stage. The virtual groups had the highest critical thinking ratio (See Table 1). The video was higher than the text critical thinking ratio except in the problem identification stage.

Table 2 provides descriptive statistics for the counts of each process category. This is a raw count of the number of units coded for each indicator in the group process category. In general, there was little evidence of group process for the virtual groups. Both the text and video groups were high in rapport building, but the video group engaged more in explaining and making a commitment than the text group did.

Discussion

Many institutions are interested in developing web-based cases particularly to accommodate distance learners. While cases represent the curriculum and serve as a stimulus, they are only one part of PBL. In fact, little is known about how case structure and presentation might impact learning even with face-to-face groups. This study suggests that the virtual group engaged in more critical thinking represented by their dialogue within the group than did the other two modalities perhaps because of the increased individual accountability required by the on-line discussion. Students may have taken more time to reflect and formulate their comments before sending responses. However, the virtual group had a reduced sense of group process.

The findings also provide some insight into the advantage of video. The text case gave the students the information; whereas, students using the video case had to first perceive the information and then struggle to articulate what they saw. Thus, the video groups were lower in critical thinking in the problem identification stage. However, this effort seemed to benefit the group discourse in other stages of critical thinking such as problem description, applicability and integration. Consider the following dialogue from text case that includes a description of a baby with altered mental status and a statement from the physician that she believes the baby is lethargic. (In this case, lethargic, a semantic qualifier or cluster of symptoms is used.) [26]

> Student 1: "I'm concerned about a couple of the descriptors that have been used, being lethargic and grunting respirations. I'm concerned that he can't sit on his own if that's something he can already do."
> Facilitator: "What does a lethargic child look like?"
> Student 2: "Sort of floppy."
> Facilitator: "Floppy?"

Student 3: "Not real interested."
Student 4: "Just not very responsive."

The facilitator has difficulty getting students to respond here. One has heard the word floppy in conjunction with lethargic but cannot describe what floppy means. Now, compare it to a discussion in a face-to-face video group after the group has watched a video of the baby with altered mental status, has heard the actor/physician say the baby is lethargic, and is questioning whether the baby is lethargic:

Student 1: "No, because he is doing the things that, I mean he looked like he was trying to struggle and he looked like he had good tone. I mean when you put him back his feet went up."
Student 2: "He's more tending toward the lethargic rather than the irritable."
Student 3: "He was still trying to wiggle around."
Student 4: "He wasn't crying."
Student 1: "He wasn't crying, wasn't pissed off, wasn't interacting, was sort of protesting."
Student 4: "Just breathing."
(The facilitator at this point begins to question students about what a normal eight-month-old should be doing. They played the video again and re-discussed his status.)

Students in the virtual group also had to perceive the information from the video case; however, each posted the facts from the case and their hypotheses before they could see the perceptions of others in the group. This component of the program encouraged individual accountability, but resulted in a high number of units in problem identification for each student. Therefore, the count of problem identification codable units often included redundant information for the virtual group.

The video information corresponded more closely to what students actually see in cases than did the text case, and the video component seemed to enhance the case discussion. Consider the following discussion:

Student 1: "It sounds like he's breathing pretty hard, pretty fast."
Student 2: "Yeah, he's making that noise. What was that noise, panting or maybe cooing?"
Student 3: "Panting."
Student 4: "Grunting."

This kind of discussion simply cannot happen with groups using a text case. In focus groups, students mentioned that the video cases made them feel as if they were caring for a real patient. [27]

Video has such a strong impact on learners because text actually is an abstract representation of reality.[28] Video brings the abstraction to a level where students can begin to describe. Dual Coding theory might suggest that having a visual example of abstract representations should promote retention of the concepts and assist students in constructing a mental model, especially when visual cues have a critical role in the diagnostic process. Norman found that experts benefited more from visual information than did students.[29] The obvious lack of clinical experience or visual examples could explain this difference and should encourage educators to include more visual examples of clinical concepts in their teaching.

The facilitator was the same for all groups because we were interested in the effects of distance and case modality without the intervening variable of facilitator effectiveness. However, by having a skilled facilitator, we may have compensated for some of the inherent weaknesses in the methods of case delivery. Alternatively, low group processing scores in the virtual group may reflect the facilitator's inexperience in developing group rapport on-line. Finally, even though this exercise was not graded, the fact that the facilitator was the course director may have affected student participation. Anderson (2001) has developed a code for assessing teaching presence that could aid us in identifying differences in facilitation in future studies.[30]

The case was kept constant for this study, but additional research would be necessary to determine whether the results could be generalized to other cases. Additionally, one could not generalize these results to computer-based cases that include different instructional strategies.

Our study examined the presence of critical thinking evident in group discourse, but we recognize other factors may enhance the learning process. We did not design the study to look at group process, but we can draw some observations. The virtual groups had far fewer units or statements in this category. Garrison (1997) believes that social climate is crucial in determining the success of a computer-based discussion.[5] This social presence is associated with the way students project themselves through the medium. Rourke (2001) created a code with 12 indicators to analyze the social presence in a computer conference.[31] Its use with the data presented here could improve our understanding of the impact of social presence on learning outcomes.

While virtual groups appear superior in critical thinking, several challenges to our results could arise. Students in virtual learning may have more carefully articulated their thoughts. About written communication, students interviewed in Fabro and Garrison's study said, "You have to think about your responses and articulate in such a way that you are able to get your response across" (p. 46).[15]

On the other hand, virtual students spent more time studying the case. The critical thinking ratios tend to adjust for the amount of discourse, but cannot adjust for the time that students may have spent in preparing their comments. Virtual university courses allowed students to attend to class in their own time and that often led to procrastination in online courses.[14] Students in PBL groups often struggle with knowing how much self-directed learning is enough. When we simulated PBL in a virtual world, even within a structured week, we found students struggled with the amount of time they should spend working on the case simulations. The content of the case should challenge the student but allow them enough time to critically analyze and construct deep meaning.

Norman and Schmidt (2000) suggested that the quality of the case in PBL relates to group functioning through which time spent on individual study relates to achievement.[32] We have explored one small aspect of case quality, its mode of presentation. We believe the data support that the video enhances critical thinking in either face-to-face or virtual PBL groups.

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Table 1. Critical Thinking (CT) Ratios by Groups for Each Stage of CT

Critical Thinking Stage	Group	N	Mean CT Ratios	Std. Dev.	p
Problem Identification	text	4	.49	.19	
	video	4	.29	.18	
	virtual	5	.92	.18	
					0.013
Problem Description	text	4	.56	.23	
	video	4	.69	.03	
	virtual	5	.95	.05	
					0.017
Problem Exploration	text	4	.52	.17	
	video	4	.56	.12	
	virtual	5	.80	.15	
					0.045
Applicability	text	4	.64	.19	
	video	4	.81	.05	
	virtual	5	.92	.11	
					0.067
Integration	text	4	.67	.04	
	video	4	.74	.15	
	virtual	5	.87	.10	
					0.059

Note: p values obtained from Kruskal-Wallis Test

Table 2. Group Process Issues: Mean counts by groups

Group	**Rapport Building**	**Explaining Process**	**Negotiating Learning Issues**	**Making a Commitment**
	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)
Text	72.14 (55)	39.00 (17.64)	1.29 (2.98)	10.29 (12.13)
Video	72.71 (47.56)	56.29 (43.19)	.43 (1.13)	28.14 (28.70)
Virtual	5.1 (4.1)	12.11 (6.37)	0	1.56 (2.13)